

MAXIM

Differential Microphone Preamplifier with Internal Bias and Complete Shutdown

MAX4063

General Description

The MAX4063 is a differential-input microphone preamplifier optimized for high-performance, portable applications. The device features two selectable inputs, differential outputs, adjustable gain, an integrated low-noise bias source, and a low-power shutdown mode. Two input paths provide both differential and single-ended microphone sensing. The high-noise rejection of the differential input is ideally suited to an internal microphone where system noise and long-run PC board traces can degrade low-level signals. The single-ended input provides a simple connection to an external microphone.

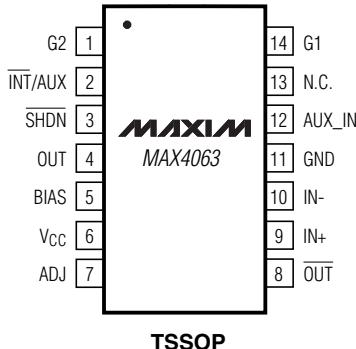
The differential and single-ended inputs have independent, adjustable gains that are set with a single external resistor. Differential outputs provide a full-scale signal of up to 6Vp-p from a single 3V supply, optimizing the dynamic range of the amplified signal. A complete shutdown mode reduces the supply current to only 0.3 μ A and disables the microphone bias for the ultimate in power savings.

The MAX4063 operates from 2.4V to 5.5V and is specified over the extended -40°C to +85°C operating temperature range. The MAX4063 is available in both 16-pin thin QFN (4mm x 4mm x 0.8mm) and 14-pin TSSOP packages.

Applications

Notebook Audio Systems
Tablet PCs
PDA Audio Systems
Signal Conditioning

Pin Configurations



Pin Configurations continued at end of data sheet.

Features

- ◆ 2.4V to 5.5V Single-Supply Operation
- ◆ Differential Inputs and Outputs
- ◆ Adjustable Gain
- ◆ High 95dB PSRR
- ◆ High 79dB CMRR
- ◆ Low-Noise, Integrated Microphone Bias
- ◆ 750 μ A Supply Current
- ◆ 0.3 μ A Shutdown Current
- ◆ $\pm 4kV$ ESD Protection (AUX_IN)
- ◆ THD+N: 0.05% at 1kHz
- ◆ Available in Space-Saving Packages
14-Pin TSSOP
16-Pin Thin QFN (4mm x 4mm x 0.8mm)

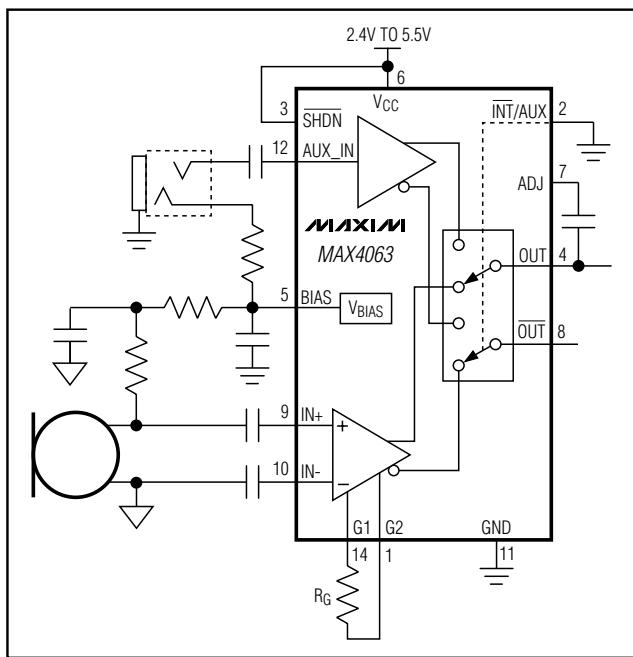
Ordering Information

PART	TEMP RANGE	PIN-PACKAGE
MAX4063ETE*	-40°C to +85°C	16 Thin QFN-EP**
MAX4063EUD	-40°C to +85°C	14 TSSOP

*Future product—contact factory for availability.

**EP = Exposed paddle.

Typical Operating Circuit

**MAXIM**

Maxim Integrated Products 1

For pricing, delivery, and ordering information, please contact Maxim/Dallas Direct! at 1-888-629-4642, or visit Maxim's website at www.maxim-ic.com.

Differential Microphone Preamplifier with Internal Bias and Complete Shutdown

ABSOLUTE MAXIMUM RATINGS

Supply Voltage (V_{CC} to GND) -0.3V to +6V
 Any Other Pin to GND -0.3V to (V_{CC} + 0.3V)
 Duration of Short Circuit to GND or V_{CC} Continuous
 Continuous Input Current (any pin) ±10mA
 Continuous Power Dissipation (T_A = +70°C) 14-Pin TSSOP (derate 9.1mW/°C above +70°C) 667mW

16-Pin Thin QFN (derate 16.9mW/°C above +70°C) 1349mW
 Operating Temperature Range -40°C to +85°C
 Storage Temperature Range -65°C to +150°C
 Lead Temperature (soldering, 10s) +300°C

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS

(V_{CC} = 3V, GND = 0V, $\overline{SHDN} = V_{CC}$, $\overline{INT/AUX} = 0V$, R_G = 11.11kΩ, R_L = 100kΩ to 1.5V, R_{BIAS} = ∞ , V_{OUT} is measured between OUT and \overline{OUT} , T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.) (Notes 1 and 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Supply Voltage Range	V _{CC}	Inferred from PSRR test	2.4	5.5	5.5	V
Supply Current	I _{CC}			0.75	1.1	mA
Output Common-Mode Voltage	V _{OCM}		1.25	1.5	1.75	V
Slew Rate	SR	A _V = 20V/V		±1		V/μs
Supply Current in Shutdown	I _{SHDN}	V _{SHDN} = 0V	0.001	1	1	μA
Output Short-Circuit Current	I _{SC}	To GND	30			mA
		To V _{CC}	30			
DIFFERENTIAL INPUT (INT/AUX = 0V)						
Input Offset Voltage	V _{OS}	T _A = +25°C		±1		mV
Common-Mode Input Voltage Range	V _{CM}	Inferred from CMRR test	1	2	2	V
Maximum Differential Input Voltage	V _{DIFFM}	A _V = 2V/V		1	1	V
Small-Signal Bandwidth	BW _{-3dB}		600			kHz
Input Resistance	R _{IN}	Either differential input	100			kΩ
Input Resistance Match	R _{MATCH}		1			%
Input Noise-Voltage Density	e _n	A _V = 20V/V, f = 1kHz	70			nV/√Hz
		A _V = 200V/V, f = 1kHz	12			
RMS Output Noise Voltage	V _{NRMS}	A _V = 20V/V, BW = 22Hz to 22kHz	225			μVRMS
Total Harmonic Distortion Plus Noise	THD+N	A _V = 20V/V, f = 1kHz, V _{OUT} = 0.7V _{RMS} , BW = 22Hz to 22kHz	0.05			%
Differential Gain	AV _{DIF}	1V < V _{CM} < 2V, V _{OUT} = 0.7V _{RMS}	RG = open	2		V/V
			RG = 11.11kΩ	19.2	20	20.8
			RG = 1.01kΩ	200		
Common-Mode Rejection Ratio	CMRR	V _{CM} = 500mV _{P-P} , f = 1kHz	70			dB
Power-Supply Rejection Ratio	PSRR	TA = +25°C	95			dB
		TA = T _{MIN} - T _{MAX}	85			
		V _{CC} = 5V ±100mV, f = 1kHz	86			

Differential Microphone Preamplifier with Internal Bias and Complete Shutdown

ELECTRICAL CHARACTERISTICS (continued)

($V_{CC} = 3V$, $GND = 0V$, $\overline{SHDN} = V_{CC}$, $\overline{INT/AUX} = 0V$, $R_G = 11.11k\Omega$, $R_L = 100k\Omega$ to $1.5V$, $R_{BIAS} = \infty$, V_{OUT} is measured between OUT and \overline{OUT} . $T_A = T_{MIN}$ to T_{MAX} , unless otherwise noted. Typical values are at $T_A = +25^\circ C$.) (Notes 1 and 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
AUXILIARY INPUT ($INT/AUX = V_{CC}$)						
Small-Signal Bandwidth	BW_{-3dB}		230			kHz
Input Resistance	R_{IN}		100			$k\Omega$
Input Noise-Voltage Density	e_n	$f = 1kHz$	200			nV/\sqrt{Hz}
RMS Output Noise Voltage	V_{NRMS}	$BW = 22Hz$ to $22kHz$	620			μV_{RMS}
Total Harmonic Distortion Plus Noise	$THD+N$	$f = 1kHz$, $BW = 22Hz$ to $22kHz$	0.007			%
Power-Supply Rejection Ratio	PSRR	$T_A = +25^\circ C$	80	100		dB
		$T_A = T_{MIN} - T_{MAX}$	72			
Voltage Gain	AV_{AUX}	$V_{OUT} = 0.7V_{RMS}$	-19.5	-20	-20.5	V/V
BIAS OUTPUT						
Output Voltage	V_{OUT}	$I_{BIAS} = 0.5mA$ to GND	2	2.2		V
Output Resistance	R_{OUT}	$I_{BIAS} = 0.5mA$ to GND	16	30		Ω
Output Noise Voltage	V_{NRMS}	$I_{BIAS} = 0.5mA$ to GND, $BW = 22Hz$ to $22kHz$	20			μV_{RMS}
Power-Supply Rejection Ratio	PSRR	$I_{BIAS} = 0.5mA$ to GND, $V_{CC} = 2.4V$ to $5.5V$	60	74		dB
		$I_{BIAS} = 0.5mA$, $V_{CC} = 3V + 100mV_{P-P}$, $f = 1kHz$		71		
DIGITAL INPUTS ($SHDN$ and INT/AUX)						
Input Leakage Current	I_{IN}	$V_{IN} = 0V$ or V_{CC}		± 1		μA
Input Voltage High	V_{INH}			$0.7 \times V_{CC}$		V
Input Voltage Low	V_{INL}				$0.3 \times V_{CC}$	V
Shutdown Enable Time	t_{ON}			10		μs
Shutdown Disable Time	t_{OFF}			10		μs

Note 1: All specifications are 100% tested at $T_A = +25^\circ C$. Specification limits over temperature ($T_A = T_{MIN}$ to T_{MAX}) are guaranteed by design, not production tested.

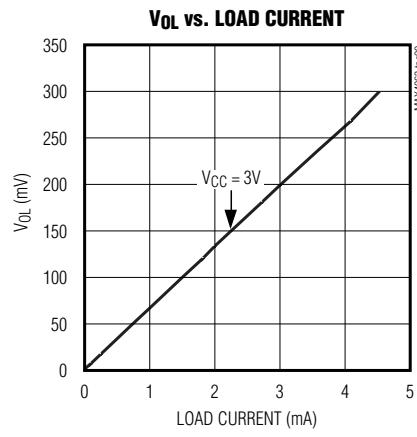
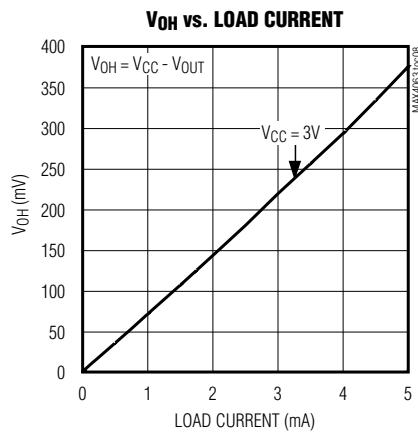
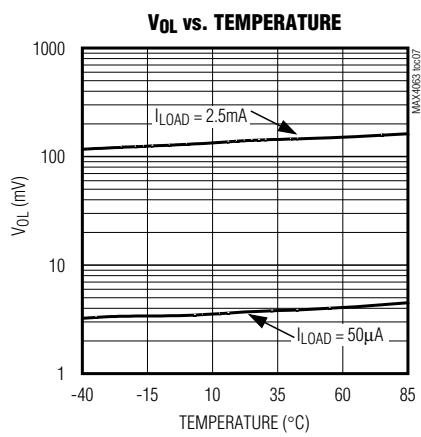
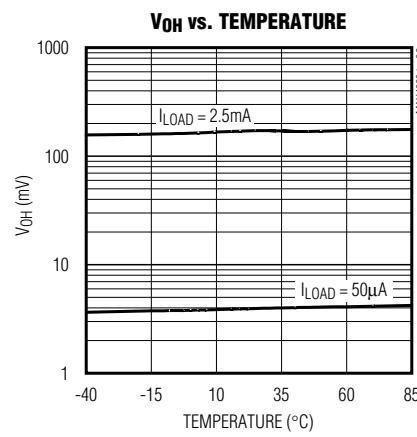
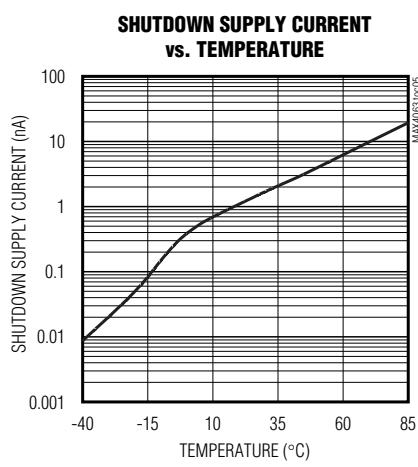
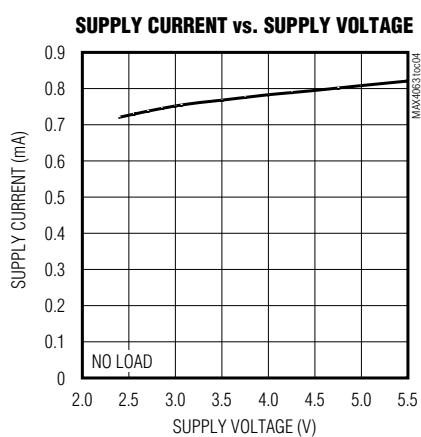
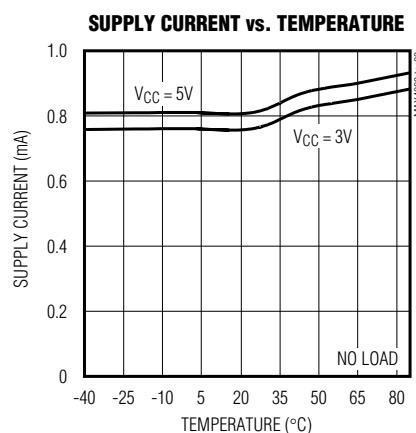
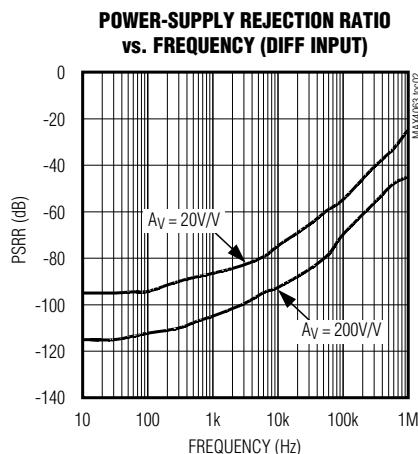
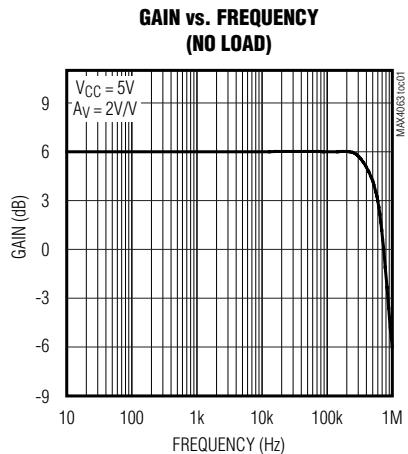
Note 2: MAX4063 requires a $1\mu F$ capacitor from BIAS to ground and a $10pF$ capacitor from ADJ to OUT.

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Differential Microphone Preamplifier with Internal Bias and Complete Shutdown

Typical Operating Characteristics

($V_{CC} = 3V$, $A_V = 20V/V$, $R_L \geq 100k\Omega$ to $1.5V$, $\overline{SHDN} = V_{CC}$, V_{OUT} is measured between OUT and \overline{OUT} . $T_A = +25^\circ C$, unless otherwise noted.)

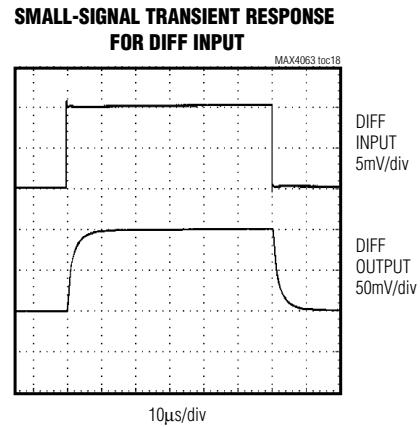
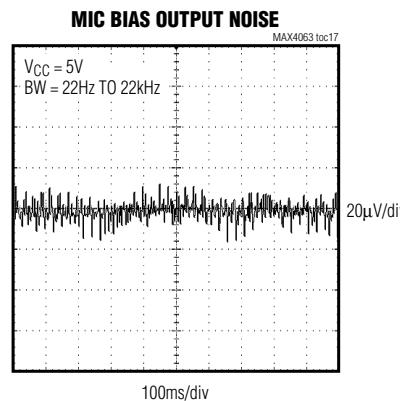
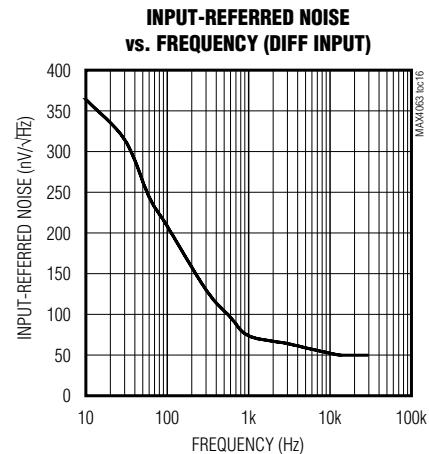
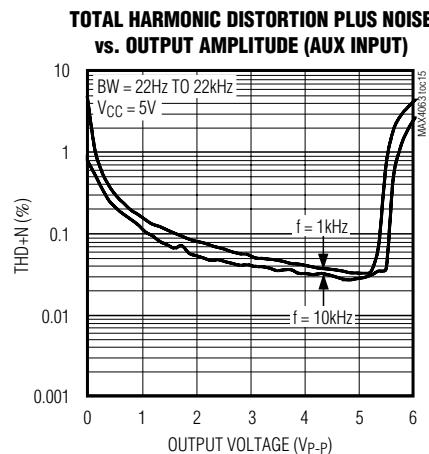
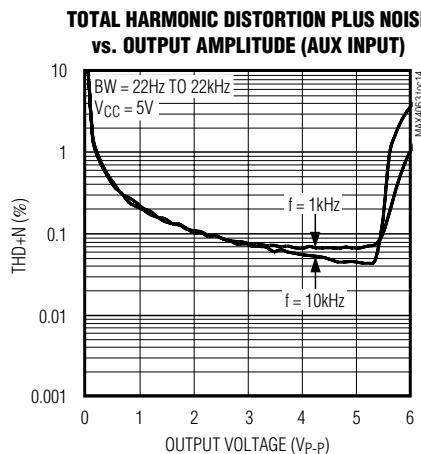
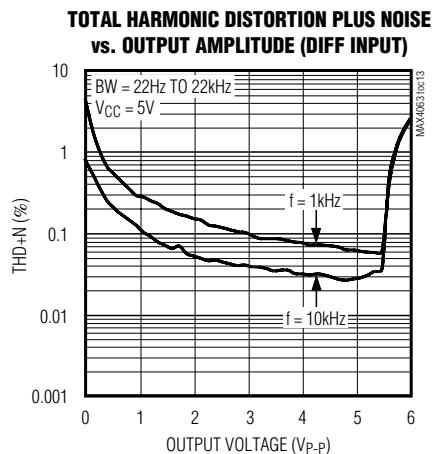
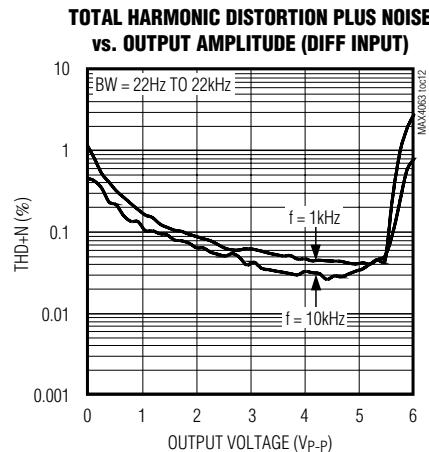
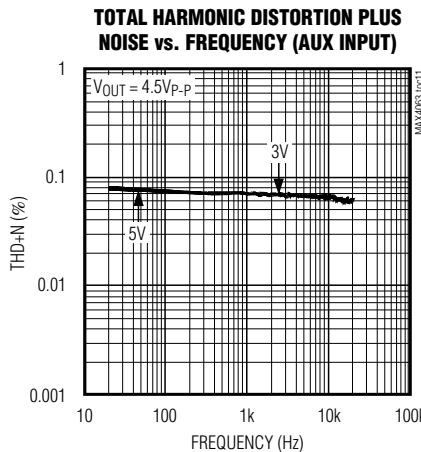
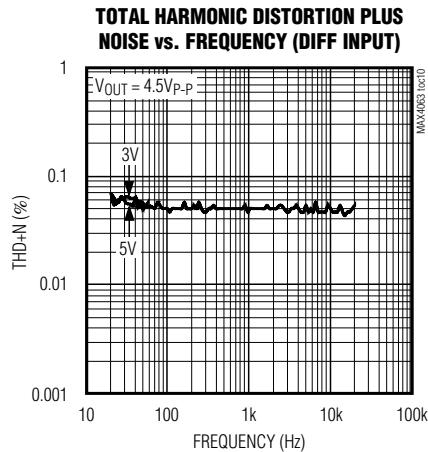


Differential Microphone Preamplifier with Internal Bias and Complete Shutdown

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Typical Operating Characteristics (continued)

($V_{CC} = 3V$, $A_V = 20V/V$, $R_L \geq 100k\Omega$ to $1.5V$, $\overline{SHDN} = V_{CC}$, V_{OUT} is measured between OUT and \overline{OUT} , $T_A = +25^\circ C$, unless otherwise noted.)

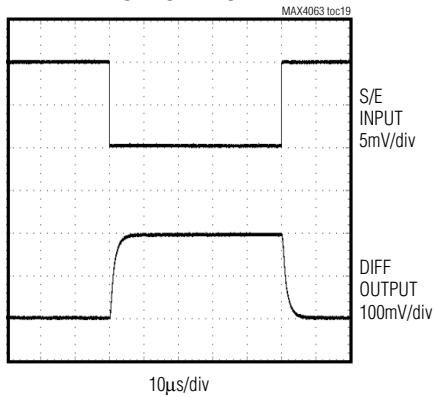


Differential Microphone Preamplifier with Internal Bias and Complete Shutdown

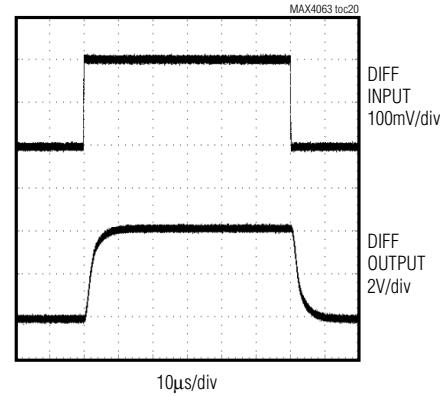
Typical Operating Characteristics (continued)

($V_{CC} = 3V$, $A_V = 20V/V$, $R_L \geq 100k\Omega$ to $1.5V$, $\overline{SHDN} = V_{CC}$, V_{OUT} is measured between OUT and \overline{OUT} . $T_A = +25^\circ C$, unless otherwise noted.)

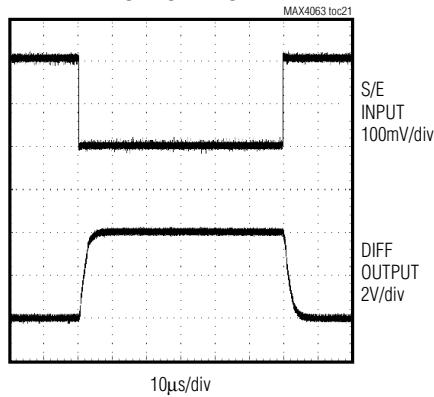
SMALL-SIGNAL TRANSIENT RESPONSE
FOR AUX INPUT



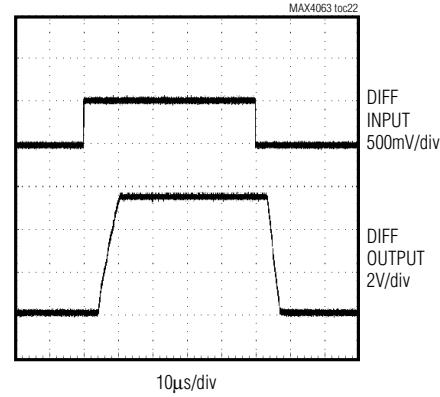
LARGE-SIGNAL TRANSIENT RESPONSE
FOR DIFF INPUT



LARGE-SIGNAL TRANSIENT RESPONSE
FOR AUX INPUT



OUTPUT OVERDRIVEN



Differential Microphone Preamplifier with Internal Bias and Complete Shutdown

Pin Description

PIN		NAME	FUNCTION
TSSOP	QFN		
1	15	G2	Gain-Selectable Input. Connect an external resistor between G1 and G2 to set the gain for the differential amplifier (see <i>Adjustable Differential Gain-Setting</i> section).
2	16	INT/AUX	Internal (Differential) or Auxiliary (Single-Ended) Input Select. Drive INT/AUX low to select differential in or high to select auxiliary in.
3	1	SHDN	Shutdown Input. Drive SHDN high for normal operation. Drive SHDN low for shutdown mode.
4	2	OUT	Amplifier Output. OUT is high impedance when in shutdown mode.
5	3	BIAS	External Electret Microphone Capsule Bias Output. Bypass BIAS with a 1 μ F capacitor to ground.
6	4	VCC	Power Supply. Bypass the VCC to GND with a 0.1 μ F capacitor.
7	5	ADJ	Adjustable Gain Select for AUX_IN (see <i>Auxiliary Input-Gain Adjustment</i> section). Connect a 10pF capacitor between OUT and ADJ.
8	7	OUT	Complementary Amplifier Output. OUT is high impedance in shutdown mode.
9	9	IN+	Noninverting Differential Amplifier Input. AC-couple the audio signal into IN+.
10	10	IN-	Inverting Differential Amplifier Input. AC-couple the audio signal into IN-.
11	11	GND	Ground
12	12	AUX_IN	Single-Ended Input for Auxiliary Microphone. AC-couple the audio signal into AUX_IN.
13	6, 8, 14	N.C.	No Connection. Not internally connected.
14	13	G1	Gain-Selectable Input. Connect an external resistor between G1 and G2 to set the gain for the differential amplifier.

Detailed Description

The MAX4063 is a differential microphone preamplifier providing high-quality amplification, optimized for use in computer and mobile applications. This device features adjustable gain, very high power-supply rejection (95dB), and common-mode rejection (79dB), making it ideal for low-noise applications. The MAX4063 provides a differential input stage, making the device particularly effective when layout constraints force the microphone amplifier to be physically remote from the ECM microphone.

The MAX4063 is capable of switching its output between the differential input and an inverting single-ended input. INT/AUX selects either the differential input or single-ended auxiliary input. In addition, the MAX4063 has an integrated microphone bias source, simplifying system design and eliminating the need for

external components. The MAX4063 has a complementary output allowing CODECs and other devices with differential inputs to be optimally driven (see *Functional Diagram*). The MAX4063 includes a 0.3 μ A shutdown mode for ultimate power savings. The differential gain of the MAX4063 is set with a single resistor connected between the G1 and G2 pins. The MAX4063 has an internal default gain of 20V/V on the AUX_IN input. The AUX_IN gain can be increased with a single external resistor (see the *Differential-Gain Adjustment* and *Auxiliary Input-Gain Adjustment* sections).

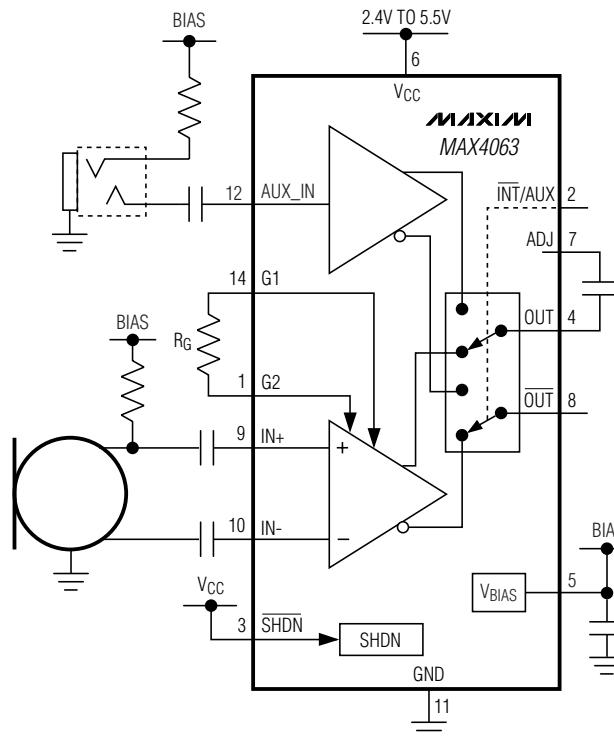
Differential Input

The main microphone amplifier is a low-noise, differential input structure. This is an almost essential element when faced with amplification of low-amplitude analog signals in digitally intense environments such as note-

MAX4063

Differential Microphone Preamplifier with Internal Bias and Complete Shutdown

Functional Diagram



book PCs or PDAs. Used correctly, the advantages over a single-ended solution are:

- Better power-supply noise rejection.
- Less degradation from noise in PC board ground planes.
- The microphone and preamplifier may be placed physically further apart, easing PC board layout restrictions.

Differential-Gain Adjustment

The MAX4063 allows the user to alter the differential gain to optimize the signal-to-noise ratio (SNR) of their system. The gain is set by a single external resistor (RG) connected between the G1 and G2 pins:

$$R_G = \frac{200\text{k}\Omega}{AVD - 2}$$

where Av is the required voltage gain.

Hence, an $11.11\text{k}\Omega$ resistor yields a gain of 20V/V , or 26dB . Leaving the pins unconnected results in a gain of 2V/V . Gain is defined as:

For differential out:

$$AVD = \frac{V_{OUT} - V_{OUT}}{V_{IN+} - V_{IN-}}$$

The resistor can be either fixed or variable, allowing the use of a digitally controlled potentiometer to alter the gain under software control.

Auxiliary Input-Gain Adjustment

The MAX4063 provides an option to increase the AUX_IN (see Figure 3). To increase the gain, connect resistor RADJ between the ADJ and AUX_IN pins. RADJ is calculated from the following formula:

$$R_{ADJ} = \frac{2\text{M}\Omega}{AV_{AUX} - 20} \text{ (to increase the gain)}$$

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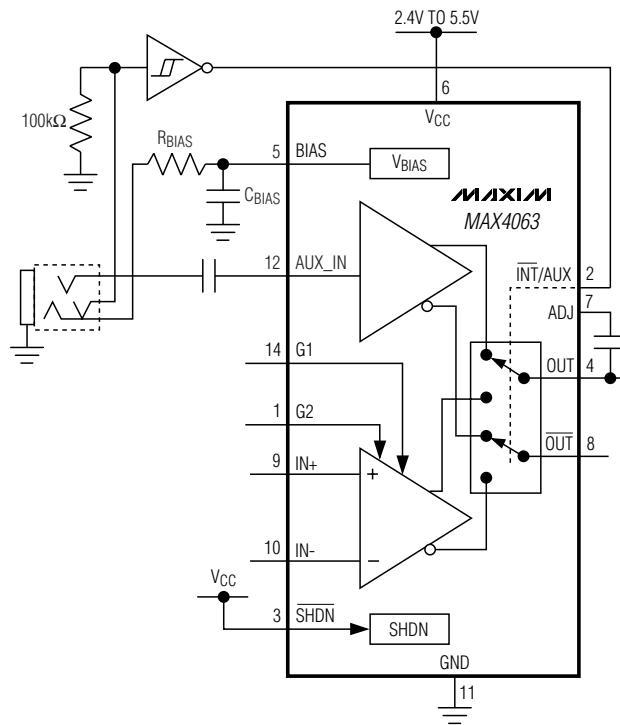


Figure 1. MAX4063 with Auxiliary Input Configuration

where:

$$AV_{AUX} = \frac{V_{OUT} - \bar{V}_{OUT}}{V_{AUX_IN}}$$

RADJ is placed between AUX_IN and ADJ.

Input Capacitors

The two differential microphone inputs and the single-ended auxiliary input of the MAX4063 have on-chip bias components, allowing the user to AC-couple any signals into the input. The input resistance is 100kΩ (typ), so the capacitor size may be chosen accordingly to define the LF rolloff desired. This can be calculated as:

$$C_{IN} = 1 / (2\pi f_{CUT} R_{IN})$$

This assumes a low source impedance is driving the inputs.

A further consideration for the differential input is the effect of these series input capacitors on low-frequency, common-mode rejection. Any mismatch in the values of these two capacitors degrades the CMRR at frequencies where the impedance of the capacitor is significant

compared to the input resistance of the amplifier—this is usually most noticeable at low frequencies. One way to avoid the need for matched or tight tolerance capacitors is to deliberately oversize the values on the differential inputs and to set the lower 3dB point (f_{CUT}) of the amplifier by sizing the output capacitor appropriately.

The input impedance matching on the differential input is typically 1%, allowing input capacitor matching to be effective at improving low-frequency PSRR.

Common-Mode Rejection Ratio

The common-mode rejection ratio (CMRR) refers to the amount of rejection that the amplifier is capable of providing to any signal applied equally to the IN+ and IN- inputs. In the case of amplifying low-level microphone signals in noisy digital environments, it is a key figure of merit. In audio circuits, this is generally measured for V_{IN} as an AC signal:

$$CMRR(dB) = ADM / ACM$$

where ADM is the differential gain, ACM is the common-mode gain.

Differential Microphone Preamplifier with Internal Bias and Complete Shutdown

Input voltages should be sufficiently small such that the output is not clipped in either differential or common-mode application. The topology used in the MAX4063 means that the CMRR actually improves at higher differential gains—another advantage of using differential sensing.

Auxiliary Input

The auxiliary input is a single-ended input intended to be used with a jack-socket type microphone input (Figure 1). Internal DC-bias components (as on the main inputs) allow the input signal to be AC-coupled. Mechanically switched jack sockets can be used in conjunction with the INT/AUX select pin, allowing the auxiliary microphone input to be automatically selected when a jack socket is inserted.

Microphone Bias Voltage

On the MAX4063 thin QFN package, connect the exposed paddle (backside of PRS) to the ground plane. The MAX4063 has an integrated low-noise, low-output impedance bias voltage. An optimum electret bias resistor can be set externally. This gives a low-noise, flexible solution that can run from 2.4V to 5.5V, which is suitable for hand-held devices such as PDAs that typically have audio power supplies in the 3V region (Figure 2).

Output

DC Bias

In shutdown mode, the bias voltage is disabled. OUT and $\overline{\text{OUT}}$ have a low-noise, DC-bias voltage independent of the power supplies, resulting in superior PSRR performance. The MAX4063 outputs are high impedance when the part is in shutdown mode.

Differential Output

The MAX4063 features a differential output stage (OUT and $\overline{\text{OUT}}$), allowing optimum performance when connected to ADCs and CODECs with differential inputs. This differential output is particularly useful in designs where the microphone preamplifier is mounted some distance away from the CODEC/ADC, as the low-impedance, differential line provides excellent noise rejection and immunity (Figure 4).

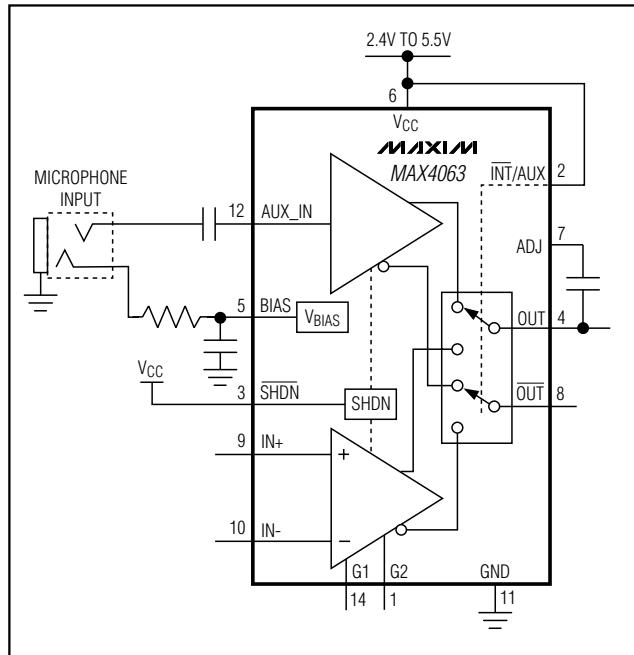


Figure 2. MAX4063 Used for Biasing a Microphone

Applications Information

Shutdown Mode

The MAX4063 features a low-power, complete shutdown mode. When SHDN goes low, the supply current drops to $0.3\mu\text{A}$, the output enters a high-impedance state, and the bias current to the microphone is switched off. Driving SHDN high enables the amplifier. SHDN should not be left floating.

Power Supplies and Layout

The MAX4063 operates from a 2.4V to 5.5V single supply. Bypass the power supply with a $0.1\mu\text{F}$ capacitor to ground. In systems where analog and digital grounds are available, the MAX4063 should be connected to the analog ground.

Differential Microphone Preamplifier with Internal Bias and Complete Shutdown

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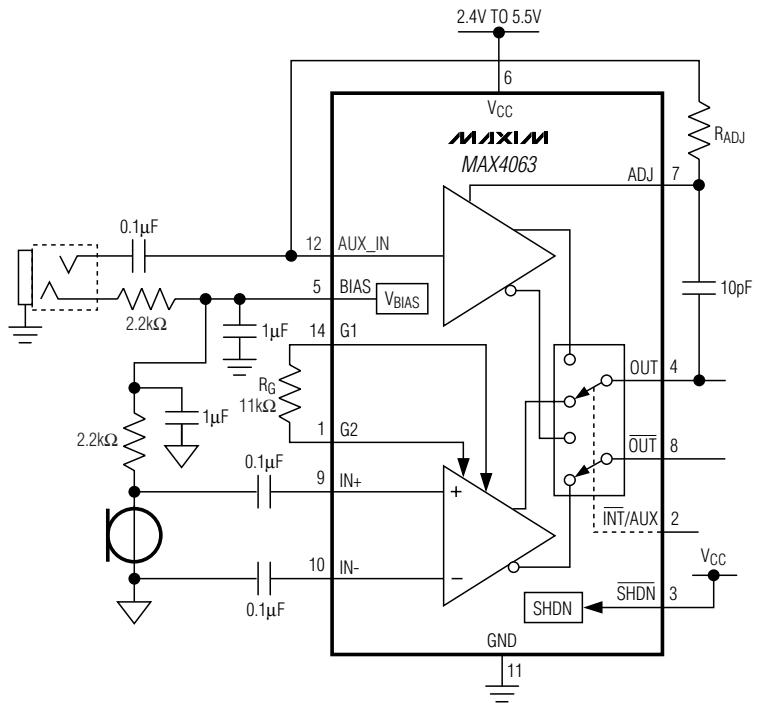


Figure 3. MAX4063 Used to Bias a Microphone Connected to the Auxiliary Input and the Differential Input

Differential Microphone Preamplifier with Internal Bias and Complete Shutdown

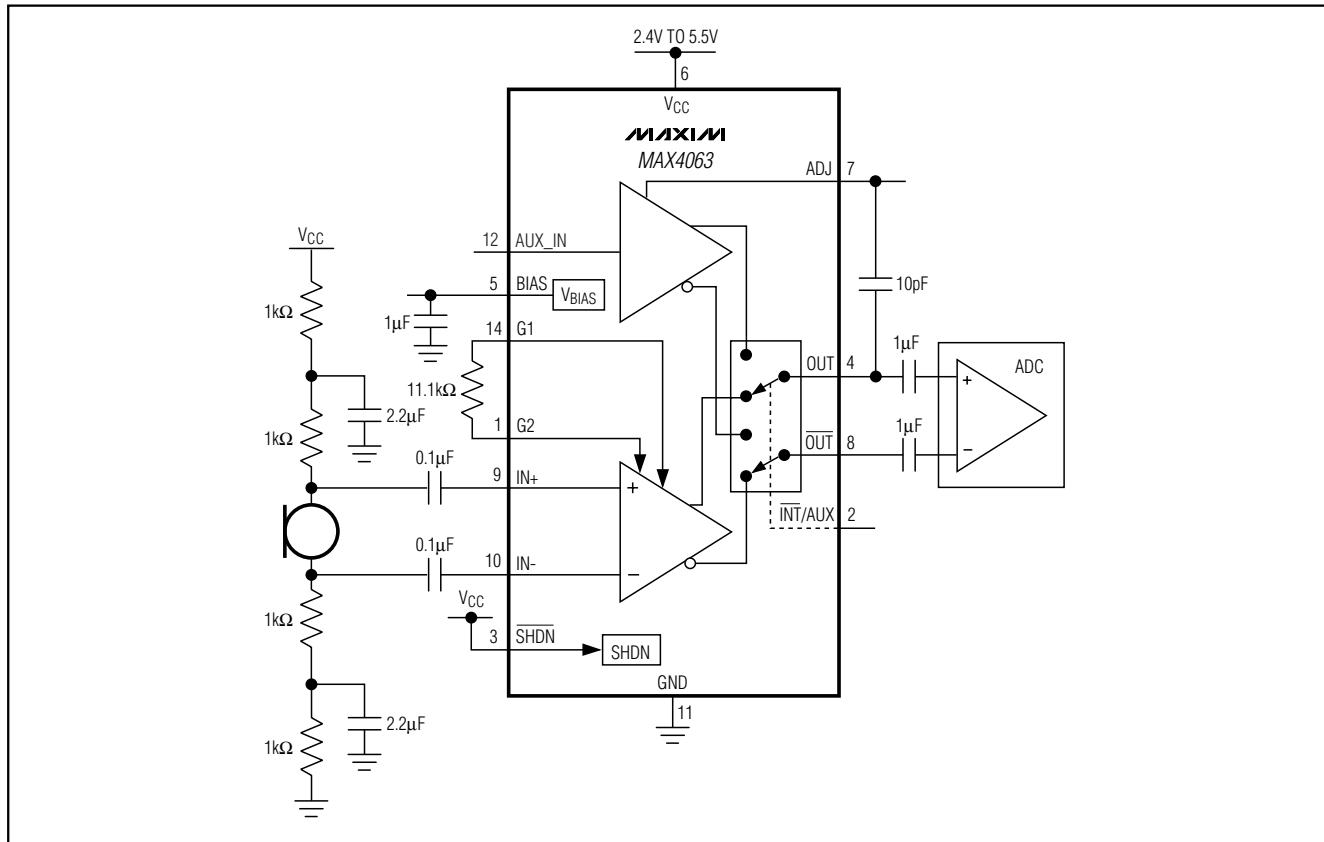
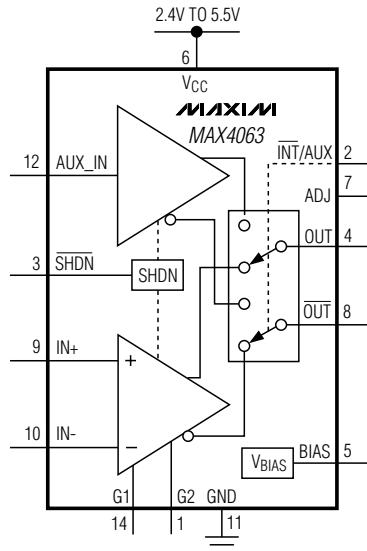


Figure 4. Using the MAX4063 with Differential Input/Differential Output Configuration

Differential Microphone Preamplifier with Internal Bias and Complete Shutdown

Simplified Block Diagram

MAX4063

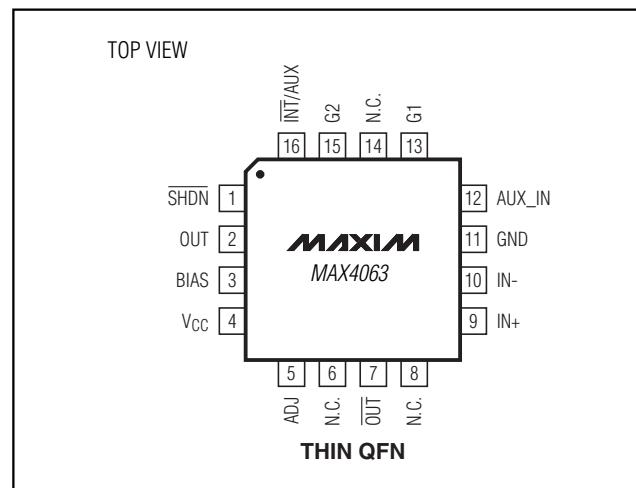


Chip Information

TRANSISTOR COUNT: 351

PROCESS: BiCMOS

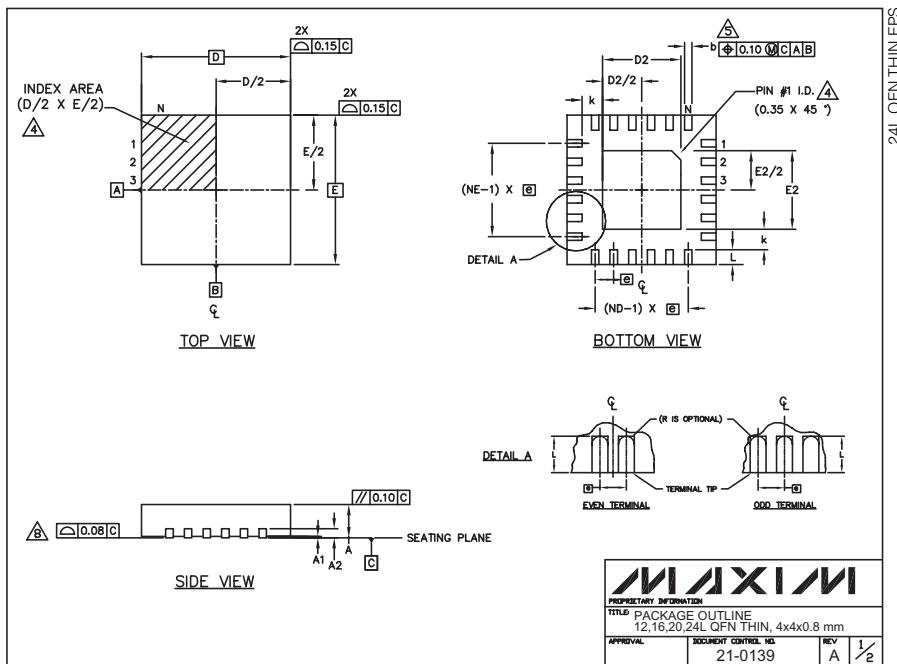
Pin Configurations (continued)



Differential Microphone Preamplifier with Internal Bias and Complete Shutdown

Package Information

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to www.maxim-ic.com/packages.)



COMMON DIMENSIONS												
PKG	12L 4x4			16L 4x4			20L 4x4			24L 4x4		
REF.	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	0.70	0.75	0.80	0.70	0.75	0.80	0.70	0.75	0.80	0.70	0.75	0.80
A1	0.0	0.02	0.05	0.0	0.02	0.05	0.0	0.02	0.05	0.0	0.02	0.05
A2	0.20 REF		0.20 REF		0.20 REF		0.20 REF		0.20 REF		0.20 REF	
b	0.25	0.30	0.35	0.25	0.30	0.35	0.20	0.25	0.30	0.18	0.23	0.30
D	3.90	4.00	4.10	3.90	4.00	4.10	3.90	4.00	4.10	3.90	4.00	4.10
E	3.90	4.00	4.10	3.90	4.00	4.10	3.90	4.00	4.10	3.90	4.00	4.10
e	0.80 BSC.		0.65 BSC.		0.50 BSC.		0.50 BSC.		0.50 BSC.		0.50 BSC.	
k	0.25	—	—	0.25	—	—	0.25	—	—	0.25	—	—
L	0.45	0.55	0.65	0.45	0.55	0.65	0.45	0.55	0.65	0.30	0.40	0.50
N	12			16			20			24		
ND	3			4			5			6		
NE	3			4			5			6		
Jedec	WGGB			WGBC			WGDD-1			WGDD-2		

EXPOSED PAD VARIATIONS

PKG CODES	D2	E2
T1244-2	1.95	2.10
T1644-2	1.95	2.10
T2044-1	1.95	2.10
T2444-1	2.45	2.60

NOTES:

1. DIMENSIONING & TOLERANCING CONFORM TO ASME Y14.5M-1994.
2. ALL DIMENSIONS ARE IN MILLIMETERS. ANGLES ARE IN DEGREES.
3. N IS THE TOTAL NUMBER OF TERMINALS.
4. THE TERMINAL #1 IDENTIFIER AND TERMINAL NUMBERING CONVENTION SHALL CONFORM TO JEDEC JESD 95-1 SPP-012. DETAILS OF TERMINAL #1 IDENTIFIER ARE OPTIONAL, BUT MUST BE LOCATED WITHIN THE ZONE INDICATED. THE TERMINAL #1 IDENTIFIER MAY BE EITHER A MOLD OR MARKED FEATURE.
5. DIMENSION b APPLIES TO METALLIZED TERMINAL AND IS MEASURED BETWEEN 0.25 mm AND 0.30 mm FROM TERMINAL TIP.
6. ND AND NE REFER TO THE NUMBER OF TERMINALS ON EACH D AND E SIDE RESPECTIVELY.
7. DEPOPULATION IS POSSIBLE IN A SYMMETRICAL FASHION.
8. COPLANARITY APPLIES TO THE EXPOSED HEAT SINK SLUG AS WELL AS THE TERMINALS.
9. DRAWING CONFORMS TO JEDEC MO220.

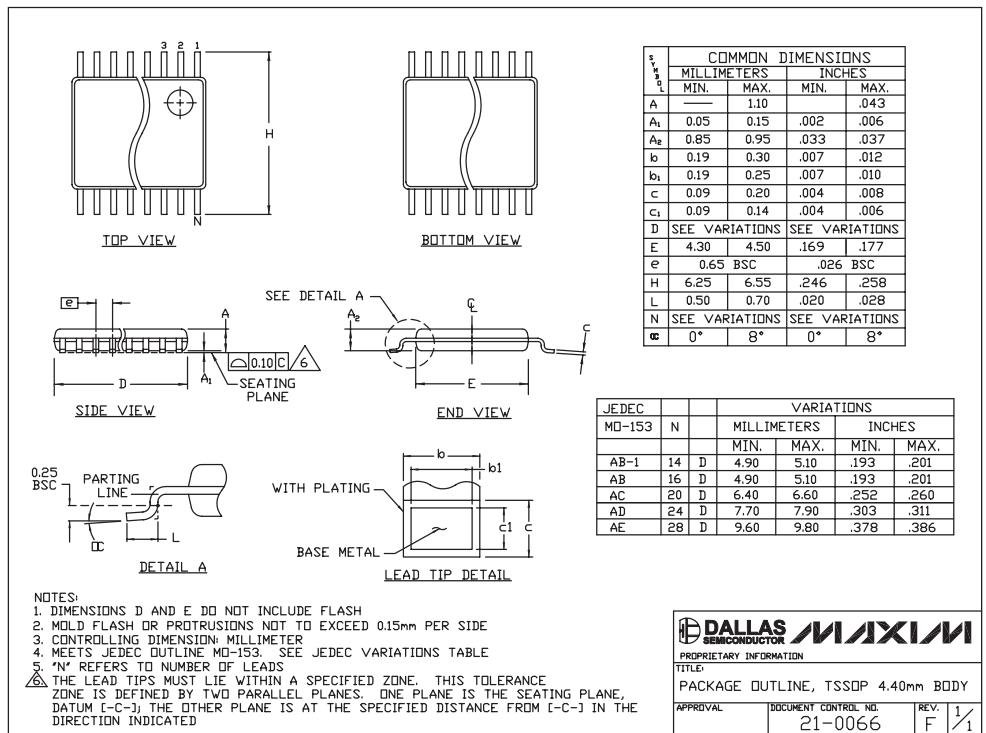
MAXIM			
PROPRIETARY INFORMATION			
TITLE: PACKAGE OUTLINE 12,16,20,24L QFN THIN, 4x4x0.8 mm			
APPROVAL: 21-0139	DOCUMENT CONTROL NO: 21-0139	REV: A	2/2

Differential Microphone Preamplifier with Internal Bias and Complete Shutdown

Package Information (continued)

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MAX4063



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